12.0 Ecological Exposure Factors

Ecological exposure factors are used in the Ecological Exposure Module of the 3MRA modeling system to calculate the total exposure dose (in mg/kg/d) to a suite of receptors that consume contaminated media and food items within their respective habitats. The Ecological Exposure Module calculates exposure doses based on media and food concentration inputs generated by other modules. The Ecological Exposure Module requires the following inputs:

- **Aquatic Food Web Module**–Contaminant concentrations in the aquatic food web.
- **Surface Impoundment Module**–Contaminant concentrations in surface impoundment water.
- **Surface Water Module**–Contaminant concentrations in surface water and sediment.
- **Terrestrial Food Web Module**–Contaminant concentrations in the terrestrial food web (including vegetation, prey items, and soil).
- **Ecological Exposure Module**–Receptor-specific values for body weight, ingestion rates, and prey preferences.
- **Site Layout Inputs**–Site-specific input on habitats, receptors, waterbodies, and prey present at a site.

The ecological exposure module calculates the exposure dose for 52 terrestrial receptor species as they occur in any of 11 ecological habitats. Table 12-1 lists the terrestrial wildlife receptors in the representative national data set. These receptors are representative of mammals, birds, and reptiles. Section 13.0 provides additional discussion about the selection of receptors and their respective habitats.

Exposure to the ecological receptors may occur through the following ingestion pathways:

- Ingestion of soil or sediment
- Ingestion of aquatic and terrestrial vegetation
- Ingestion of aquatic and terrestrial prey items
- Ingestion of surface water.

Table 12-1. Exposure Data Sources for Terrestrial Wildlife Receptors

Species	Scientific Name	References
Alligator snapping turtle	*Macroclemys temminckii*	Lane and Mitchell, 1997; Conant and Collins, 1991
American kestrel	*Falco sparverius*	Terres, 1980; U.S. EPA, 1993; Lane and Fischer, 1997; Stokes and Stokes, 1996
American robin	*Turdus migratorius*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
American woodcock	*Scolopax minor*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Bald eagle	*Haliaeetus leucocephalus*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Beaver	*Castor canadensis*	Stokes and Stokes, 1986; Whitaker, 1997; Jenkins and Busher, 1979
Belted kingfisher	*Ceryle alcyon*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Black bear	*Ursus americanus*	Schaefer and Sargent, 1990; Stokes and Stokes, 1986; Whitaker, 1997
Black-tailed jackrabbit	*Lepus californicus*	Whitaker, 1997; Sample et al., 1997; MacMahon, 1985
Burrowing owl	*Speotyto cunicularia*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
Canada goose	*Branta canadensis*	Terres, 1980; U.S. EPA, 1993; Niering, 1985; Stokes and Stokes, 1996
Cerulean warbler	*Dendroica cerulea*	Evans and Fischer, 1997; Terres, 1980; Stokes and Stokes, 1996
Cooper's hawk	*Accipiter cooperi*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
Coyote	*Canis latrans*	Bekoff, 1977; Sample et al, 1997; Whitaker, 1997; Stokes and Stokes, 1986
Deer mouse	*Peromyscus maniculatus*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Eastern box turtle	*Terrapene carolina*	Martof et al., 1980; U.S. EPA, 1993; Sutton and Sutton, 1985; Conant and Collins, 1991
Eastern cottontail rabbit	*Sylvilagus floridanus*	Stokes and Stokes, 1986; Chapman et al., 1980; Whitaker, 1997; U.S. EPA, 1993
Great blue heron	*Ardea herodias*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996; Niering, 1985
Great Basin pocket mouse	*Perognathus parvus*	Whitaker, 1997; Sample et al., 1997
Green heron	*Butorides virescens*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996; Niering, 1985
Herring gull	*Larus argentatus*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Kit fox	*Vulpes velox*	McGrew, 1979; Sample et al., 1997; MacMahon, 1985; Whitaker, 1997

(continued)

Table 12-1. (continued)

Species	Scientific Name	References
Least weasel	*Mustela nivalis*	Whitaker, 1997; Stokes and Stokes, 1986; Sample et al., 1997
Lesser scaup	*Aythya affinis*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Little brown bat	*Myotis lucifugus*	Whitaker, 1997; Sample et al., 1997.
Loggerhead shrike	*Lanius ludovicianus*	Hall et al., 1997; Terres, 1980; Stokes and Stokes, 1996
Long-tailed weasel	*Mustela frenata*	Sutton and Sutton, 1985; Sample et al., 1997; Stokes and Stokes, 1996
Mallard	*Anas platyrhynchos*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996; Niering, 1985
Marsh wren	*Cistothorus palustris*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996; Niering, 1985
Meadow vole	*Microtus pennsylvanicus*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Mink	*Mustela vison*	Niering, 1985; U.S. EPA, 1993; Whitaker, 1997; Stokes and Stokes,1986
Mule deer	*Odocoileus hemionus*	Whitaker, 1997; Sample et al., 1997; Anderson and Wallmo, 1984; Whitney, 1985
Muskrat	*Ondatra zibethicus*	Niering, 1985; U.S. EPA, 1993; Stokes and Stokes, 1986; Willner et al., 1980; Whitaker, 1997
Northern water snake	*Nerodia sipedon*	Martof et al., 1980; U.S. EPA, 1993; Conant and Collins, 1991; Niering, 1985; Behler and King, 1979
Northern bobwhite	*Colinus virginianus*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Osprey	*Pandion haliaetus*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Painted turtle	*Chrysemys picta*	Niering, 1985; U.S. EPA, 1993; Conant and Collins, 1991; Behler and King, 1979
Pine vole	*Microtus pinetorum*	Whitaker, 1997; Sample et al., 1997
Prairie vole	*Microtus ochrogaster*	Whitaker, 1997; U.S. EPA, 1993
Raccoon	*Procyon lotor*	Lotze and Andersen, 1979; U.S. EPA, 1993; Whitaker, 1997; Stokes and Stokes, 1986
Racer	*Coluber constrictor*	Behler and King, 1979; U.S. EPA, 1993; Conant and Collins, 1991; Martof et al., 1980
Red fox	*Vulpes vulpes*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Red-tailed hawk	*Buteo jamaicensis*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
River otter	*Lutra canadensis*	Whitaker, 1997; U.S. EPA, 1993; Niering, 1985; Stokes and Stokes, 1986

(continued)

Table 12-1. (continued)

Species	Scientific Name	References
Short-tailed shrew	*Blarina brevicauda*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Short-tailed weasel	*Mustela erminea*	King, 1983; Sample et al., 1997; Whitaker, 1997
Snapping turtle	*Chelydra serpentina*	Martof et al., 1980; U.S. EPA, 1993; Behler and King, 1979; Conant and Collins, 1991
Southern hognose snake	*Heterodon simus*	Behler and King, 1979; Jordan, 1998; Martoff et al., 1980; Conant and Collins, 1991
Spotted sandpiper	*Actitis macularia*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Tree swallow	*Tachycineta bicolor*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
Western meadowlark	*Sturnella neglecta*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
White-tailed deer	*Odocoileus virginianus*	Whitaker, 1997; Stokes and Stokes, 1986; Smith, 1991

The pathways through which each receptor species may be exposed were determined by the species' dietary preferences. For example, strict herbivores are exposed through ingestion of vegetation but not through ingestion of animal prey items; species whose diet includes animal prey are exposed through prey ingestion, and so on. Exposures through ingestion of soil, sediment, and surface water was determined by the documented foraging and feeding behavior of each species.

The generalized equation for calculating ecological exposure dose is the following:

$$Dose_{rec} = \left[\frac{(CR_{food} \bullet FoodConc_{HabRange}) + (CTssAve_{HabRange} \bullet CR_{food} \bullet CRfrac_{soil}) + ConcWaterTotAve_{HabRange} \bullet CR_{water})}{BodyWt_{Rec}}\right] \bullet AreaFrac_{HabRange} \quad (12\text{-}1)$$

where

CR_{food} = consumption rate of food

$FoodConc_{HabRange}$ = effective concentration in all food items, weighted by prey preferences

$CtssAve_{HabRange}$ = average contaminant concentration in surficial soil in a home range

$CRfrac_{soil}$ = soil dietary fraction for each receptor

$ConcWaterTotAve_{HabRange}$	=	total average concentration in water for each home range
CR_{water}	=	consumption rate of water
$BodyWt_{Rec}$	=	receptor body weight
$AreaFrac_{HabRange}$	=	fraction of the receptor's home range comprised by the habitat.

12.1 Parameters Collected

The variables used in the Ecological Exposure Module are shown in Table 12-2, along with the data source and notes on whether the variable is represented by a distribution or a fixed value. The body weight and ingestion rate parameters are characterized by fixed values; dietary composition, or the amount of each food item eaten, is characterized by a uniform distribution between reported minimum and maximum values. In addition, the variable PreyType is addressed in this section. While no data collection was required for this parameter, prey items were assigned to nine prey categories (PreyType) for use in the Ecological Exposure Module.

In general, the ecological exposure factors are for the mean adult body weight for the species; male and female weights are combined, and juvenile body weights are not considered. Although some data are reported by age or sex, not enough of these data exist to develop exposure factors for juveniles or for males versus females for an adequate number of species. Moreover, age- or sex-specific uptake factors and toxicological benchmarks are not available for ecological receptors. Therefore, consumption rates and prey preferences were estimated for average adults only.

Dietary composition for each receptor species varies depending on habitat. For example, raccoons are assumed to eat a variety of vegetation and animal prey wherever they occur; however, when they occur in waterbody margin habitats, aquatic prey are included in their dietary composition. In an upland forest or a residential habitat, only terrestrial prey are included.

12.2 Data Sources

The following documents were the principal data sources for the ecological exposure factors used in the representative national data set:

- U.S. EPA (Environmental Protection Agency). 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187. Office of Research and Development, Washington, DC. December.

- Sample, B.E., M.S. Alpin, R.A. Efroymson, G.W. Suter, and C.J.E. Welsh. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants*. ORNL/TM-13391, Office of Environmental Policy and Assistance. Oak Ridge National Laboratory, Oak Ridge, TN. October.

Table 12-2. Parameters Collected

Variable Name	Description	Principal Data Sources	Distribution/Fixed Value
BodyWt_rec	Body weight for each receptor	U.S. EPA, 1993; Sample et al., 1997; American Society of Mammalogists,[a] U.S. Army Corps of Engineers[2]	Fixed (mean)
CR_food	Food consumption rate for each receptor	U.S. EPA, 1993	Fixed (for mean body weight)
CR_water	Water consumption rate for each receptor	U.S. EPA, 1993	Fixed (for mean body weight)
CRfrac_sed	Percentage of food consumption consisting of sediment	U.S. EPA, 1993	Fixed
CRfrac_soil	Percentage of food consumption consisting of soil	U.S. EPA, 1993	Fixed
MinPreyPref_HabRange	Minimum dietary preference for food items found in home range	U.S. EPA, 1993; Sample et al., 1997; American Society of Mammalogists,[a] U.S. Army Corps of Engineers[b]	Minimum, uniform distribution assumed
MaxPreyPref_HabRange	Maximum dietary preference for food items found in home range	U.S. EPA, 1993; Sample et al., 1997; American Society of Mammalogists,[a] U.S. Army Corps of Engineers[b]	Maximum, uniform distribution assumed
$AreaFrac_{HabRange}$[c]	Home range size	U.S. EPA, 1993; Sample et al., 1997; American Society of Mammalogists,[a] U.S. Army Corps of Engineers[b]	Fixed

[a] The American Society of Mammalogists' *Mammalian Species Series* comprises individually published monographs on single species. Authors and dates of publication vary for each species.

[b] The U.S. Army Corps of Engineers' *Species Profile Series* comprises individually published monographs on single species. Authors and dates of publication vary for each species.

[c] Home range size data were used in the site layout data processing step to calculate $AreaFrac_{HabRange}$. Although home range size is not a variable used directly by the ecological exposure module, these data were collected from the same sources as other species-specific exposure factors and are documented in this section.

- U.S. Army Corps of Engineers' *Species Profile Series*. Various authors and publication dates.

- American Society of Mammalogists' *Mammalian Species Series*. Various authors and publication dates.

Table 12-2 indicates the principal data source for each parameter. For species-specific body weight, dietary composition, and home range size, the primary source of data was the *Wildlife Exposure Factors Handbook* (the *Handbook*) (U.S. EPA, 1993). The *Handbook* is the best available compendium of information relevant to ecological exposure. It includes exposure factors for 34 species of mammals, birds, amphibians, and reptiles. All species included in the *Handbook* (U.S. EPA, 1993) have been included in the 3MRA modeling system exposure factor database, with the exception of the harbor seal, which inhabits estuarine and marine habitats not addressed in the example data set. In addition, algorithms for estimating ingestion rates based on body weight were taken from the *Handbook* (U.S. EPA, 1993).

Similar data for an additional 15 species of birds and mammals (Black-tailed jackrabbit, burrowing owl, Cooper's hawk, coyote, Great Basin pocket mouse, green heron, kit fox, little brown bat, least weasel, long-tailed weasel, short-tailed weasel, mule deer, pine vole, tree swallow, and western meadowlark) were taken from Sample et al. (1997). The species addressed in Sample et al. (1997) were chosen by the authors specifically to complement those in the *Handbook* (U.S. EPA, 1993), and thus provide complementary data.

The American Society of Mammalogists' *Mammalian Species Series* provided additional prey preference, home range size, and body weight data on seven of the species in the *Handbook* (U.S. EPA, 1993) and Sample et al. (1997), and provided primary data for an additional two mammals (beaver and white-tailed deer).

The U.S. Army Corps of Engineers' *Species Profile Series* provided data on eight additional species – one mammal, two reptiles, two amphibians, and three birds. These species profiles are part of a study of wildlife species on military reservations in the southeastern United States and, therefore, emphasize species found in that region. Of the receptors selected from this source, however, only the amphibians and reptiles (alligator snapping turtle, southern hognose snake, gopher frog and flatwoods salamander) are restricted to the southeastern United States. Because data on herpetofauna are generally scarce, these four species are included in the receptor list, although they are included in the exposure analysis only at sites located within their respective areas of distribution.

Additional sources were identified to supplement the prey preference data from the principal sources. The dietary information in the *Handbook* (U.S. EPA, 1993) and Sample et al. (1997) consists of reported food items from field studies. Thus, the data reflect the dietary composition of a single or a few individuals at particular study sites, in some cases over a relatively short time period. The 3MRA modeling system exposure assessment, on the other hand, is based on hypothetical food webs intended to reflect all of the receptor species' potential dietary items. As such, the prey preference data required by the ecological exposure module should reflect the potential food intake for the species in all habitats and regions where it occurs. Therefore, more generalized dietary composition data were taken from numerous field guides

and wildlife encyclopedias (e.g., several of the National Audubon Society field guides and the Peterson field guides; Terres, 1980; Martof et al., 1980). All references used to collect ecological exposure data are listed in Table 12-1 and in the reference section (Section 12.5).

Soil and sediment ingestion data were taken from the *Handbook* (U.S. EPA, 1993) and from several additional references, each with data on one or a few species. See Section 12.3.4 for further discussion of these data sources.

12.3 Methodology

Methods for developing exposure factors from wildlife data extracted from various sources are detailed in the *Handbook* (U.S. EPA, 1993). Those methods were followed substantially in the data collection effort for the representative national data set. Based on information in the *Handbook* (U.S. EPA, 1993) and in the other sources listed previously, a database was developed containing all available data relevant to ecological exposures for the 52 selected receptor species. Most of the data were extracted from the *Handbook* (U.S. EPA, 1993) and from Sample et al. (1997). Both the *Handbook* (U.S. EPA, 1993) and Sample et al. (1997) are compilations of data from many different references and, therefore, include multiple values for each species for a particular data category (e.g., multiple body weights for otter). In some cases, the reported values are the mean of the data collected for a single study; in other cases, the reported values reflect a single measurement. In all cases, all reported values were entered into the database, including means, minima, and maxima. Single reported values were entered as mean values. Data collected from additional sources were treated in the same manner. These data were then processed to generate the appropriate inputs for the module. The following subsections document the data processing methods for each ecological exposure parameter. Section 12.3.6 addresses the quality assurance and quality control (QA/QC) of data collection and processing.

12.3.1 Receptor Body Weights

Data on the body weights of individual receptor species were taken from several primary sources that represent a compilation of the results of many separate studies. The primary sources used included the following:

- U.S. EPA (1993)
- Sample et al. (1997)
- American Society of Mammalogists' *Mammalian Species Series*
- U.S. Army Corps of Engineers' *Species Profile Series*.

Values were collected and assembled in the ecological exposure database. Then, a mean value was calculated so that a single datum represented body weight for each species. When data from multiple studies were reported in a single reference (e.g., the *Handbook* [U.S. EPA, 1993]), the geometric mean of the adult body weights from each study was calculated. In some cases, body weight data were presented separately for males and females. In this instance, the average of the geometric means for males and females was used. Body weights collected from field guides generally consisted of average adult values. Body weights identifiable as juvenile or preadult weights were not included in the species average. The mean body weights represent

data from multiple local investigations as well as from national or regional averages. They are assumed to collectively represent a national mean.

The following assumptions are inherent in this manipulation of body weight data:

- Some reported data are accompanied by an indication of the age of the individual studied; age data are relevant to body weights. In some cases, an age in months or years is reported, while in others a life stage such as fledgling, juvenile, or subadult is reported. These data were standardized in the database to indicate adults for individuals that have reached sexual maturity and juveniles for all other ages.

- Individual body weights were derived to represent receptors nationally. This derivation was generally based on local scale data from studies distributed throughout the United States. For some species, however, only one or a few reported body weights were available.

- A single value is assumed to represent both males and females.

12.3.2 Food Ingestion Rates

Food and water consumption rates were calculated for each receptor species using Nagy's (1987) allometric equations as reported in the *Handbook* (U.S. EPA, 1993). The equations correlate food and water intake to body weight in free-living wildlife species. Separate regression equations were used for mammals and birds. The equations and associated values follow.

Food ingestion rate

$$Y = aWt^{b} \qquad (12\text{-}2)$$

where

Y = food ingestion rate, g DW/d
Wt = representative body weight of receptor species, g WW
a = empirical coefficient
b = empirical coefficient.

Mean adult body weights were estimated as described in Section 12.3.1. The values used for the empirical coefficients a and b, as presented in the *Handbook* (U.S. EPA, 1993), are presented in Table 12-3. The estimations were based on average, gender-neutral body weights and do not account for differences in size, season, habitat, or activity level. Ingestion rates were subsequently converted to a wet weight basis assuming 85 percent moisture content of food.

Table 12-3. Empirical Coefficients Used to Calculate Food Ingestion Rates

Species Group/Subgroup	a	b
Birds	0.64	0.651
Mammals	0.23	0.822

Source: U.S. EPA, 1993.

12.3.3 Water Ingestion Rates

Receptor species' consumption rates for water also were derived based on body weights. Calder and Braun (1983), as cited in the *Handbook* (U.S. EPA, 1993), developed an equation for drinking water ingestion for birds. This equation is presented in Equation 12-3.

Water ingestion rate for birds

$$WI = 0.059 \cdot Wt^{0.67} \quad (12\text{-}3)$$

where

WI = drinking water ingestion, L/d
Wt = representative body weight of receptor species, kg.

This equation was derived based on a data set representing 21 species with a body weight range of 11 to 3,150 g. Birds, in general, drink less water than mammals of equivalent body weight. Calder and Braun (1983) developed a parallel equation for mammals, as shown in Equation 12-4.

Drinking water ingestion for mammals

$$WI = 0.099 \cdot Wt^{0.90} \quad (12\text{-}4)$$

where

WI = drinking water ingestion, L/d
Wt = representative body weight of receptor species, kg.

No similar allometric equation is available for relating body weight to drinking water ingestion for reptiles and amphibians. Therefore, a default value of 0.0001 was used for water ingestion in all herpetofauna.

The following assumptions are inherent in the derivation of the receptor species drinking water ingestion rates:

- The estimations were based on average, gender-neutral body weights and do not account for differences in size, season, habitat, or activity level.

- Additional sources of water, including water derived from ingested food, were not accounted for. Depending on dietary composition, some species derive more water from food items than do others.

12.3.4 Consumption Rate of Surficial Soil/Sediment

Consumption rates for surficial soil and sediment were taken from the *Handbook* (U.S. EPA, 1993) and the following additional references:

- Arthur and Gates (1988)
- Arthur and Alldredge (1979)
- Beyer et al. (1994)
- Mayoh and Zach (1986).

Sediment and soil ingestion rates were reported as a fraction of the total dietary ingestion. The fractions were applied to the ingestion rates estimated as described in Section 12.3.2. The values were reported as sediment/soil ingestion rates, without distinguishing what proportion was sediment versus soil. The Ecological Exposure Module, however, uses discreet constituent concentrations in soil and sediment. Therefore, receptor species were assigned soil or sediment ingestion as a function of their feeding patterns. Those species feeding entirely on terrestrial prey and food items were assumed to consume soil, and the reported sediment/soil ingestion rate was applied entirely to soil. Those receptors feeding on aquatic prey and food items, or on a combination of aquatic and terrestrial prey and food items, were assumed to ingest only sediment.

For those species for which sediment/soil ingestion rates were not available, the reported ingestion rate of the most similar species was used. Similarity was based first on faunal class (i.e., mammal, bird, reptile, amphibian), second on size, and third on feeding behavior. Data were available for only two species of herpetofauna, the eastern box turtle and the painted turtle. Therefore, small herpetofauna with mixed diets (e.g., frogs, salamanders) were given the same rate as the eastern box turtle, and larger herpetofauna that eat a significant proportion of fish (e.g., snapping turtles and aquatic snakes) were given the same rate as the painted turtle.

The following assumptions are inherent in the derivation of the receptor species' surficial soil/sediment ingestion rates:

- Soil and sediment ingestion were treated as mutually exclusive because the data do not specify which medium was reported. Many receptors probably ingest a combination of soil and sediment (e.g., raccoon).

- Data on soil ingestion were lacking for most receptor species; therefore, available values were used for species expected to have a similar diet and feeding behavior.

12.3.5 Maximum/Minimum Dietary Preferences

The Ecological Exposure Module includes an algorithm to construct a unique, randomly selected diet for each receptor species at each site where it occurs. This algorithm reflects the variability in receptor species' dietary composition. Dietary preference data required by the ecological exposure model includes a list of potential diet items for each species and the maximum and minimum proportion of the species' diet that each item can comprise. Diet items are categorized as one of 17 types of prey recognized by the 3MRA modeling system. The prey categories are shown in Table 12-4.

Table 12-4. Prey Categories

Worms	Trophic level (T4) fish
Other invertebrates	Aquatic plants
Small mammals	Exposed fruit
Small birds	Exposed vegetables
Small herpetofauna	Forage
Herbivorous vertebrates	Grains
Omnivorous vertebrates	Roots
Benthic filter feeders	Silage
Trophic level (T3) fish	

For example, prey preference data on the Eastern box turtle are as follows:

Diet Item	Percentage of Diet
Worms	3 to 60
Forage	13 to 39
Fruits	5 to 33
Other invertebrates	8 to 22
Small herpetofauna	0 to 10
Small mammals	0 to 10

Information on receptor species' dietary composition comes from a wide range of data sources and is of two general types. Some data consist of reported quantities of certain items eaten by particular individuals in a localized or site-specific study. These data consist of measured stomach contents, nest or burrow contents, or counts of items observed to be eaten during a particular time span. The principal sources for this type of data are the *Handbook* (U.S. EPA, 1993) and Sample et al. (1997). The second type of information consists of qualitative reports of items documented to be eaten. These reports reflect a compilation of observations and measurements for the species in general and are reported as descriptions of the species' potential diet. The principal sources of this type of data are the Army Corps of Engineers' *Species Profile*

Series, the American Society of Mammalogists' *Mammalian Species Series*, and the various field guides and handbooks listed in Table 12-1.

The Ecological Exposure Module requires data on the full range of potential diet items across all habitats where each species could occur. In addition, it requires quantified data – maxima and minima. Therefore, the two general types of data for each receptor were combined, and dietary profiles were developed for each receptor species. The profiles include each documented diet item for each species, whether the item was reported in a quantitative or qualitative form. Maximum and minimum values were generated for each item through a subjective process implemented by project ecologists. In this process, the qualitative information was evaluated, and an estimated dietary fraction was assigned to each item. Then, all reported and estimated dietary fractions were compared, and the minimum and maximum values were identified for each diet item.

The assignment of estimated dietary fractions was made by a single ecologist to maintain consistency in interpreting qualitative descriptions. In addition, certain decision rules were followed for all assignments. References to a diet item that implied a single most significant component, such as "primary food source," "bulk of the diet," and "consumes mostly," were assigned a minimum of 50 percent dietary composition. Items that are of secondary importance but that would always make up at least some portion of the diet were assigned a minimum of 10 percent. Descriptions implying occasional sources of food were given a minimum of zero (thus indicating that some individuals under some circumstances do not consume the item at all) and a maximum of 25 percent. A few species have relatively limited diets and eat only one diet item. For example, the cerulean warbler eats insects almost exclusively. In these cases, the exclusive diet item (insects) was assigned a minimum of 95 percent and a maximum of 100 percent. The quantified dietary profiles were entered into the exposure factor database as maximum and minimum values for each prey category.

The different data sources report vegetative dietary constituents in various terms ranging from a list of food items by species name to general categories such as seeds and nuts or vegetation. Consequently, the data for vegetation constituents were standardized in the database using terms recognized by the exposure module and coded according to farm food chain codes for compatibility with the farm food chain and terrestrial food web modules. Table 12-5 shows the food categories most frequently reported in the literature and their respective farm food chain codes.

Assumptions inherent in the processing of these data include the following:

- Data from a variety of sources were collected and combined to represent receptor species' diets; therefore, the values used were intended to be representative of the species throughout their range and habitat types.

- Qualitative diet information was subjectively interpreted and given numeric values. These values were combined with site- or study-specific quantitative data to derive maximum and minimum values.

Table 12-5. Farm Food Chain Codes for Wildlife Diet Items

Farm Food Chain Code	Dietary Items Included
Forage	Forbs, grass(es), other plant(s), plant(s), shrubs, terrestrial plants, trees, unclassified plant(s), unidentified plant(s), vegetation, woody plants
Silage	Crops, corn
Grains	Seeds, nuts
Exposed fruit	Fruits, fruits/seeds (reported as a single item)
Exposed vegetation	Fern(s), fungi, fungus, cactus, dicot shoots, monocot shoots
Root	Root

- When fish were a reported dietary item, the fish's trophic level was included for use in the aquatic food web module. When the fish species name was reported, its trophic level was extracted from trophic level analyses in EPA's Great Lakes Study (U.S. EPA, 1995). In all other cases, the trophic level for fish prey was assumed to be T3 or T4 based on the size of the predator (receptor species). Small receptors were assumed to eat T3 fish. For large receptors, it was assumed that 50 percent of the fish they eat are T3 and 50 percent are T4. None of the primary exposure data sources included information on the trophic level of prey items.

12.3.6 Home Range Size

Home range, or territory size, was used to estimate the proportion of the diet taken from the potentially contaminated area. For species with very small territories (e.g., mice, voles), the entire home range is likely to fall within the contaminated area. For larger or wider ranging species (e.g., the bald eagle), much of a receptor's diet could come from outside the contaminated area. The variable used in the ecological exposure module to reflect the proportion of a receptor's diet taken from the contaminated area is $AreaFrac_{HabRange}$. Home range size data were used in the site layout data processing step to calculate $AreaFrac_{HabRange}$ by dividing the species' home range area by the area of the species' habitat located on a site. A detailed discussion of the $AreaFrac_{HabRange}$ variable is presented in the documentation of the ecological exposure module.

Home range data were available for all but 9 of the 52 receptor species and were found primarily in the *Handbook* (U.S. EPA, 1993), Sample et al. (1997), the Army Corps of Engineers' *Species Profile Series*, and the American Society of Mammalogists' *Mammalian Species Series*. Species for which no data were available were assigned the home range size of a similar species with similar feeding habits. Various metrics are reported in the literature for the size of the area used by a receptor. These metrics include feeding or foraging radius, feeding or foraging distance, and home range or territory size. In most cases (particularly, the *Handbook*

[U.S. EPA, 1993]), the terminology for area size was discussed and defined. In other sources, when no definition of terms was provided, judgments were made based on the context of the data and comparison with other reports on the same species. In most cases, the size of the area used by a species for foraging and feeding was reported in hectares or acres and referred to as the home range or territory. When a linear distance was reported, it was assumed to represent a radius. When a radius was reported, it was assumed to describe a circular area around a nest or some essential physical feature. All home range size data were entered into the exposure factors database, and the midpoint between the minimum and maximum values was calculated for each species. The home ranges were assumed to be circular.

In the site layout processing step, receptor species' home ranges were placed within delineated habitats where the species occur. Section 13.0 provides a full description of habitat delineation and placement of home ranges. As explained in Section 13.0, home range placement proved inordinately resource-intensive. Therefore, a binning approach was adopted to reduce the number of home ranges that required placement in a geographic information system (GIS). Using this approach, each receptor's average home range size was assigned to one of four bins. Each bin comprised a range of home range sizes, as follows:

- Bin 1 – Home range = or <100,000 m^2
- Bin 2 – Home range >100,000 m^2 and <1 million m^2
- Bin 3 – Home range = or >1 million m^2, and <10 million m^2
- Bin 4 – Home range = or >10 million m^2.

Because receptor exposure dose, as calculated in the ecological exposure module, is adjusted based on the proportion of the home range that falls within the contaminated area, the binning approach potentially underestimates the exposure dose for receptors at the low end of each range. For example, the meadow vole has an average home range size of 416 m^2; however, because it falls within Bin 1, its home range is assumed to be 100,000 m^2. Thus, the proportion of the meadow vole's diet taken from contaminated habitat will be calculated as the proportion of the 100,000-m^2 home range that falls within the contaminated area. Obviously, in certain cases, this will be a significantly smaller proportion of the diet than would be estimated if the true mean home range size (416 m^2) were used.

The following assumptions are inherent in the processing of home range size data:

- Calculated averages were assumed to reflect the home range size for a species in all of the habitats where it occurs, while available data may come from a single habitat type. In fact, habitat type and quality affect foraging distance. For example, a white-tailed deer may cover a larger area when foraging in a forest than when feeding in a crop field.

- Average home range sizes also were assumed to reflect all regions of the United States and year-round food availability. Some reported home range data were for particular regions and seasons; no attempt was made to distinguish home range size by region or season.

12.3.7 Data Entry and Data Processing Quality Assurance/Quality Control

The QA/QC functions for data collection of ecological exposure factors consist of ensuring that data have been interpreted and extracted correctly (i.e., Technical QA/QC) and verifying that data have been entered correctly (i.e., data entry QA/QC). Detailed QA records are maintained by the project QA Officer (QAO).

12.3.7.1 Technical Quality Assurance/Quality Control. The sources used to obtain the exposure factor data are considered to be authoritative references and, therefore, data extracted from them are assumed to be of high quality. Data extracted from primary literature sources have been reviewed by senior ecologists to determine the quality of the exposure factors. Methods for extracting and combining data (e.g., calculating mean values) as well as the assumptions used for interpreting and standardizing data (e.g., assigning age data as adult or juvenile or assigning food types to farm food chain categories) were developed with the oversight and review of senior ecologists.

12.3.7.2 Data Entry Quality Assurance/Quality Control. Entry of raw data into the exposure factors database was checked against the source by a staff member other than the one who entered the data. At least 50 percent of entries from each source were checked. All data processing, such as calculation of means, was checked by a staff member other than the one who performed the calculation or set up the calculation spreadsheet. A QA check of at least 10 percent of the results of the spreadsheet macros used to manipulate data was made against the original spreadsheets.

12.4 Results

Tables presenting the ecological exposure data used in the 3MRA modeling system are presented in the appendixes to this section. Appendix 12A includes the following tables:

- Table 12A-1 – Mean body weights by receptor
- Table 12A-2 – Food ingestion rates for mean body weight by receptor
- Table 12A-3 – Water ingestion rates for mean body weight by receptor
- Table 12A-4 – Soil ingestion rates as a fraction of total ingestion
- Table 12A-5 – Sediment ingestion rates as a fraction of total ingestion.

Appendix 12B includes prey preference tables:

- Table 12B-1 – Minimum prey preferences
- Table 12B-2 – Maximum prey preferences.

Appendix 12C includes receptor home ranges and assignments to size bins.

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Appendix 12A

Ecological Exposure Factors

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Table 12A-1. Mean Adult Body Weight (kg)

Receptor Index	Receptor Species	$BodyWt_{Rec}$
1	Alligator snapping turtle	50.40
2	American kestrel	0.12
3	American robin	0.08
4	American woodcock	0.18
5	Bald eagle	3.75
6	Beaver	19.31
7	Belted kingfisher	0.15
8	Black bear	128.87
9	Black-tailed jackrabbit	2.42
11	Burrowing owl	0.15
12	Canada goose	3.00
13	Cerulean warbler	0.01
14	Cooper's hawk	0.40
15	Coyote	13.13
16	Deer mouse	0.02
17	Eastern box turtle	0.38
18	Eastern cottontail rabbit	1.23
22	Great Basin pocket mouse	0.02
23	Great blue heron	2.23
25	Green heron	0.23
26	Herring gull	1.09
27	Kit fox	1.80
28	Least weasel	0.04
29	Lesser scaup	0.79
30	Little brown bat	0.01
31	Loggerhead shrike	0.05
32	Long-tailed weasel	0.19
33	Mallard duck	1.17
34	Marsh wren	0.01
35	Meadow vole	0.02
36	Mink	0.99
37	Mule deer	75.47
38	Muskrat	0.87
39	Northern bobwhite	0.19
40	Northern water snake	0.21

(continued)

Table 12A-1. (continued)

Receptor Index	Receptor Species	$BodyWt_{Rec}$
41	Osprey	1.60
42	Painted turtle	0.24
43	Pine vole	0.03
44	Prairie vole	0.04
45	Raccoon	5.69
46	Racer	0.11
47	Red fox	4.53
48	Red-tailed hawk	1.13
49	River otter	8.66
50	Short-tailed shrew	0.02
51	Short-tailed weasel	0.20
52	Snapping turtle	5.30
53	Southern hognose snake	0.10
54	Spotted sandpiper	0.04
55	Tree swallow	0.02
56	Western meadowlark	0.11
57	White-tailed deer	69.42

Table 12A-2. Food Ingestion Rates (kg/d wet weight)

Receptor Index	Receptor Species	CR_Food (kg/d ww)
1	Alligator snapping turtle	0.35
2	American kestrel	0.10
3	American robin	0.072
4	American woodcock	0.12
5	Bald eagle	0.91
6	Beaver	5.1
7	Belted kingfisher	0.11
8	Black bear	24
9	Black-tailed jackrabbit	0.93
11	Burrowing owl	0.11
12	Canada goose	0.78
13	Cerulean warbler	0.018
14	Cooper's hawk	0.21
15	Coyote	3.7
16	Deer mouse	0.018
17	Eastern box turtle	0.0079
18	Eastern cottontail rabbit	0.53
22	Great Basin pocket mouse	0.016
23	Great blue heron	0.65
25	Green heron	0.15
26	Herring gull	0.41
27	Kit fox	0.73
28	Least weasel	0.032
29	Lesser scaup	0.33
30	Little brown bat	0.0092
31	Loggerhead shrike	0.052
32	Long-tailed weasel	0.11
33	Mallard duck	0.42
34	Marsh wren	0.020
35	Meadow vole	0.019
36	Mink	0.45
37	Mule deer	16
38	Muskrat	0.40
39	Northern bobwhite	0.13

(continued)

Table 12A-2. (continued)

Receptor Index	Receptor Species	CR_Food (kg/d ww)
40	Northern water snake	0.0050
41	Osprey	0.52
42	Painted turtle	0.0055
43	Pine vole	0.022
44	Prairie vole	0.033
45	Raccoon	1.9
46	Racer	0.0031
47	Red fox	1.6
48	Red-tailed hawk	0.41
49	River otter	2.6
50	Short-tailed shrew	0.014
51	Short-tailed weasel	0.12
52	Snapping turtle	0.060
53	Southern hognose snake	0.0028
54	Spotted sandpiper	0.049
55	Tree swallow	0.031
56	Western meadowlark	0.089
57	White-tailed deer	15

Table 12A-3. Water Ingestion Rates (L/d)

Receptor Index	Receptor Species	CR_Water (kg/d)
1	Alligator snapping turtle	0.00010
2	American kestrel	0.014
3	American robin	0.011
4	American woodcock	0.019
5	Bald eagle	0.14
6	Beaver	1.4
7	Belted kingfisher	0.016
8	Black bear	7.8
9	Black-tailed jackrabbit	0.22
11	Burrowing owl	0.017
12	Canada goose	0.12
13	Cerulean warbler	0.0025
14	Cooper's hawk	0.032
15	Coyote	1.00
16	Deer mouse	0.0029
17	Eastern box turtle	0.00010
18	Eastern cottontail rabbit	0.12
22	Great Basin pocket mouse	0.0026
23	Great blue heron	0.10
25	Green heron	0.022
26	Herring gull	0.063
27	Kit fox	0.17
28	Least weasel	0.0056
29	Lesser scaup	0.050
30	Little brown bat	0.0014
31	Loggerhead shrike	0.0076
32	Long-tailed weasel	0.022
33	Mallard duck	.066
34	Marsh wren	.0028
35	Meadow vole	0.0030
36	Mink	0.098
37	Mule deer	4.8
38	Muskrat	0.088
39	Northern bobwhite	0.019

(continued)

Table 12A-3. (continued)

Receptor Index	Receptor Species	CR_Water (kg/d)
40	Northern water snake	0.00010
41	Osprey	0.081
42	Painted turtle	0.00010
43	Pine vole	0.0036
44	Prairie vole	0.0057
45	Raccoon	0.47
46	Racer	0.00010
47	Red fox	0.39
48	Red-tailed hawk	0.064
49	River otter	0.69
50	Short-tailed shrew	0.0035
51	Short-tailed weasel	0.023
52	Snapping turtle	0.00010
53	Southern hognose snake	0.00010
54	Spotted sandpiper	0.0071
55	Tree swallow	0.0044
56	Western meadowlark	0.013
57	White-tailed deer	4.5

Table 12A-4. Soil Ingestion Rates (percent of total ingestion)

Receptor Index	Receptor Species	CRfrac_soil
2	American kestrel	1
3	American robin	1
4	American woodcock	10.4
8	Black bear	2.8
9	Black-tailed jackrabbit	6.3
11	Burrowing owl	1
12	Canada goose	8.2
13	Cerulean warbler	0
14	Cooper's hawk	1
15	Coyote	2.8
16	Deer mouse	2
18	Eastern cottontail rabbit	6.3
22	Great Basin pocket mouse	2
27	Kit fox	2.8
28	Least weasel	1
30	Little brown bat	0
31	Loggerhead shrike	1
32	Long-tailed weasel	2.8
35	Meadow vole	2.4
37	Mule deer	6.8
39	Northern bobwhite	9.3
43	Pine vole	2.4
44	Prairie vole	2.4
46	Racer	1
47	Red fox	2.8
48	Red-tailed hawk	1
50	Short-tailed shrew	1
51	Short-tailed weasel	2.8
53	Southern hognose snake	1
55	Tree swallow	1
56	Western meadowlark	0
57	White-tailed deer	6.8

Table 12A-5. Sediment Ingestion Rates (percent of total ingestion)

Receptor Index	Receptor Species	CRfrac_sed
1	Alligator snapping turtle	5.9
5	Bald eagle	5.9
6	Beaver	3.3
7	Belted kingfisher	5.9
17	Eastern box turtle	4.5
23	Great blue heron	9.4
25	Green heron	9.4
26	Herring gull	5.9
29	Lesser scaup	3.3
38	Mallard duck	3.3
34	Marsh wren	0
36	Mink	9.4
38	Muskrat	3.3
40	Northern water snake	5.9
41	Osprey	5.9
42	Painted turtle	5.9
45	Raccoon	9.4
49	River otter	9.4
52	Snapping turtle	5.9
54	Spotted sandpiper	10.4

Appendix 12B

Dietary Preferences for Terrestrial Food Web

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Table 12B-1a. Minimum Prey Preferences in Terrestrial Habitats (percent of diet)

	Worms	Other invertebrates	Small mammals	Herbivorous vertebrates	Omnivorous vertebrates	Small birds	Benthic filter feeders	T3 Fish	T4 Fish	Aquatic plants	Exposed fruits	Exposed vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small herpetofauna
Numprey Numreceptor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Alligator snapping turtle	-999	0	0	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0.2
2 American kestrel	0	0.25	0	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.02
3 American robin	0.15	0.08	-999	-999	-999	-999	-999	-999	-999	-999	0.07	-999	0	-999	-999	-999	0.01	-999	-999	-999
4 American woodcock	0.6	0.01	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	-999	0.01	-999	-999	-999
5 Bald eagle	-999	0	0.1	0	0	0.02	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
6 Beaver	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.2	-999	0.01	-999	0.01	-999	-999	-999
7 Belted kingfisher	-999	0.2	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	-999	0.01	-999	-999	0
8 Black bear	-999	0.3	0.01	0	0	-999	-999	-999	-999	-999	0.3	0	0.05	-999	0	0	0.01	-999	-999	0
9 Black-tailed jackrabbit	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.9	-999	-999	-999	0.01	-999	-999	-999
11 Burrowing owl	-999	0.01	0.09	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
12 Canada goose	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.2	0.2	0	0.2	0.01	-999	-999	-999
13 Cerulean warbler	-999	0.95	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
14 Cooper's hawk	-999	-999	0.15	-999	-999	0.29	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
15 Coyote	-999	0.01	0.05	0	0	0.03	-999	-999	-999	-999	0.05	-999	-999	-999	-999	-999	0.01	-999	-999	0
16 Deer mouse	-999	0.07	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0	0	0.12	-999	-999	0.01	-999	-999	-999
17 Eastern box turtle	0.03	0.08	0	-999	-999	-999	-999	-999	-999	-999	0.05	0	0.13	-999	-999	-999	0.01	-999	-999	0
18 Eastern cottontail	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.17	-999	-999	0	0.01	-999	-999	-999
22 Great Basin pocket mouse	-999	0.2	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0.2	-999	-999	0.01	-999	-999	-999
23 Great blue heron	-999	0.02	0.03	-999	-999	0	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999	0.01	-999	-999	0.04
25 Green heron	0	0.01	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	-999	0.01	-999	-999	0.01
26 Herring gull	0	0.1	0.05	-999	-999	0.01	-999	-999	-999	-999	0	-999	0	-999	-999	-999	0.01	-999	-999	0
27 Kit fox	-999	0	0.25	0.2	0.2	0	-999	-999	-999	-999	0	-999	0	-999	-999	-999	0.01	-999	-999	0

(continued)

Table 12B-1a. (continued)

	Worms	Other invertebrates	Small mammals	Herbivorous vertebrates	Omnivorous vertebrates	Small birds	Benthic filter feeders	T3 Fish	T4 Fish	Aquatic plants	Exposed fruits	Exposed vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small herpetofauna
28 Least weasel	-999	0	0.5	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
29 Lesser scaup	-999	0.1	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	0.1	-999	-999	0.01	-999	-999	-999
30 Little brown bat	-999	0.95	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
31 Loggerhead shrike	-999	0.24	0.28	-999	-999	0.28	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
32 Long-tailed weasel	0	0	0.14	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
33 Mallard duck	-999	0.1	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	0.5	0	0	0.01	-999	-999	-999
34 Marsh wren	-999	0.95	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
35 Meadow vole	-999	0.01	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0	0.5	0	0.01	0	0.01	-999	-999	-999
36 Mink	-999	0	0.1	0.1	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.02
37 Mule deer	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.1	0	0.5	0	-999	0	0.01	-999	-999	-999
38 Muskrat	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0.02	0	0	-999	0.01	-999	-999	0
39 Northern bobwhite	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	0.21	-999	-999	0.01	-999	-999	-999
40 Northern water snake	-999	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.14
41 Osprey	-999	-999	0	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
42 Painted turtle	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
43 Pine vole	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0.25	0	0.25	-999	0.01	-999	-999	-999
44 Prairie vole	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0.5	0	0.1	-999	0.01	-999	-999	-999
45 Raccoon	0	0	0	-999	-999	0	-999	-999	-999	-999	0.25	-999	0.1	0	0	0	0.01	-999	-999	0
46 Racer	-999	0.1	0.1	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.1
47 Red fox	-999	0	0.1	0	0	0	-999	-999	-999	-999	0.1	-999	0	-999	-999	-999	0.01	-999	-999	-999
48 Red-tailed hawk	0	0	0.1	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
49 River otter	-999	0	0	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
50 Short-tailed shrew	0.25	0.1	0	-999	-999	-999	-999	-999	-999	-999	0	0	-999	-999	-999	-999	0.01	-999	-999	-999
51 Short-tailed weasel	-999	0	0.5	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
52 Snapping turtle	0	0.1	0	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
53 Southern hognose snake	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.5

(continued)

Table 12B-1a. (continued)

	Worms	Other invertebrates	Small mammals	Herbivorous vertebrates	Omnivorous vertebrates	Small birds	Benthic filter feeders	T3 Fish	T4 Fish	Aquatic plants	Exposed fruits	Exposed vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small herpetofauna
54 Spotted sandpiper	-999	0.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
55 Tree swallow	-999	0.5	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	-999	-999	-999	0.01	-999	-999	-999
56 Western meadowlark	-999	0.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	0.01	-999	-999	-999
57 White-tailed deer	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.1	0	0.5	0	-999	0	0.01	-999	-999	-999

-999 denotes a null value. The species does not consume the particular receptor.

Table 12B-1b. Minimum Prey Preferences in Waterbody Margin and Wetland Margin Habitats (percent of diet)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
Numprey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Numreceptor																				
1 Alligator Snapping Turtle	-999	0	0	-999	-999	-999	0.2	0.2	0.2	0	0	-999	-999	-999	-999	-999	-999	0.01	0.01	0.2
2 American Kestrel	0	0.25	0	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.02
3 American Robin	0.15	0.08	-999	-999	-999	-999	-999	-999	-999	-999	0.07	-999	0	-999	-999	-999	0.01	-999	-999	-999
4 American Woodcock	0.6	0.01	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	-999	0.01	-999	-999	-999
5 Bald Eagle	-999	0	0.1	0	0	0.02	-999	0.25	0.25	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	0
6 Beaver	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.1	-999	-999	0.2	-999	0.01	-999	0.01	0.01	0.01	-999
7 Belted Kingfisher	-999	0.2	0	-999	-999	-999	0	0.5	-999	-999	-999	-999	0	-999	-999	-999	0.01	0.01	0.01	0
8 Black Bear	-999	0.3	0.01	0	0	-999	0	0	0	-999	0.3	0	0.05	-999	0	0	0.01	0.01	0.01	0
9 Black-Tailed Jack Rabbit	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.9	-999	-999	-999	0.01	-999	-999	-999
11 Burrowing Owl	-999	0.01	0.09	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
12 Canada Goose	-999	0	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	0.2	0.2	0	0.2	0.01	0.01	0.01	-999
13 Cerulean Warbler	-999	0.95	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
14 Cooper's Hawk	-999	-999	0.15	-999	-999	0.29	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
15 Coyote	-999	0.01	0.05	0	0	0.03	-999	-999	-999	-999	0.05	-999	-999	-999	-999	-999	0.01	-999	-999	0
16 Deer Mouse	-999	0.07	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0	0	0.12	-999	-999	0.01	-999	-999	-999
17 Eastern Box Turtle	0.03	0.08	0	-999	-999	-999	-999	-999	-999	-999	0.05	0	0.13	-999	-999	-999	0.01	-999	-999	0
18 Eastern Cotton Tail	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.17	-999	-999	0	0.01	-999	-999	-999
22 Great Basin Pocket Mouse	-999	0.2	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0.2	-999	-999	0.01	-999	-999	-999
23 Great Blue Heron	-999	0.02	0.03	-999	-999	0	0	0.05	0.05	0.01	-999	-999	0.01	-999	-999	-999	0.01	0.01	0.01	0.04
25 Green Heron	0	0.01	0	-999	-999	-999	-999	0.4	-999	0	-999	-999	0	-999	-999	-999	0.01	0.01	0.01	0.01
26 Herring Gull	0	0.1	0.05	-999	-999	0.01	0.1	0.05	0.05	0	0	-999	0	-999	-999	-999	0.01	0.01	0.01	0
27 Kit Fox	-999	0	0.25	0.2	0.2	0	-999	-999	-999	-999	0	-999	0	-999	-999	-999	0.01	-999	-999	0
28 Least Weasel	-999	0	0.5	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999

(continued)

Table 12B-1b. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
29 Lesser Scaup	-999	0.1	-999	-999	-999	-999	0	-999	-999	0	0	-999	0	0.1	-999	-999	0.01	0.01	0.01	-999
30 Little Brown Bat	-999	0.95	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
31 Loggerhead Shrike	-999	0.24	0.28	-999	-999	0.28	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
32 Long-Tailed Weasel	0	0	0.14	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	-999
33 Mallard Duck	-999	0.1	-999	-999	-999	-999	0	0	-999	0	0	-999	0	0.5	0	0	0.01	0.01	0.01	-999
34 Marsh Wren	-999	0.95	-999	-999	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	0.01	-999
35 Meadow Vole	-999	0.01	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0	0.5	0	0.01	0	0.01	-999	-999	-999
36 Mink	-999	0	0.1	0.1	-999	0	-999	0	0	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	0.02
37 Mule Deer	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.1	0	0.5	0	-999	0	0.01	-999	-999	-999
38 Muskrat	-999	-999	-999	-999	-999	-999	0	0	-999	0.12	-999	0	0.02	0	0	-999	0.01	0.01	0.01	0
39 Northern Bobwhite	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	0.21	-999	-999	0.01	-999	-999	-999
40 Northern Water Snake	-999	0	0	-999	-999	-999	0	0.5	0.3	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.14
41 Osprey	-999	-999	0	-999	-999	0	-999	0.25	0.25	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	0
42 Painted Turtle	-999	0	-999	-999	-999	-999	-999	0	-999	0.5	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	-999
43 Pine Vole	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0.25	0	0.25	-999	0.01	-999	-999	-999
44 Prairie Vole	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0.5	0	0.1	-999	0.01	-999	-999	-999
45 Raccoon	0	0	0	-999	-999	0	0	0	0	-999	0.25	-999	0.1	0	0	0	0.01	0.01	0.01	0
46 Racer	-999	0.1	0.1	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.1
47 Red Fox	-999	0	0.1	0	0	0	-999	-999	-999	-999	0.1	-999	0	-999	-999	-999	0.01	-999	-999	-999
48 Red-Tailed Hawk	0	0	0.1	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
49 River Otter	-999	0	0	-999	-999	0	0	0.25	0.25	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	0
50 Short-Tailed Shrew	0.25	0.1	0	-999	-999	-999	-999	-999	-999	-999	0	0	-999	-999	-999	-999	0.01	-999	-999	-999
51 Short-Tailed Weasel	-999	0	0.5	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0
52 Snapping Turtle	0	0.1	0	-999	-999	0	0.1	0.1	0.1	0.1	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	0
53 Southern Hognose Snake	-999	-999	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0.01	-999	-999	0.5

(continued)

Table 12B-1b. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
54 Spotted Sandpiper	-999	0.5	-999	-999	-999	-999	0	0	-999	-999	-999	-999	-999	-999	-999	-999	0.01	0.01	0.01	-999
55 Tree Swallow	-999	0.5	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	-999	-999	-999	0.01	-999	-999	-999
56 Western Meadow Lark	-999	0.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	-999	0.01	-999	-999	-999
57 White-Tailed Deer	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0.1	0	0.5	0	-999	0	0.01	-999	-999	-999

-999 denotes a null value. The species does not consume the particular receptor.

Table 12B-2a. Maximum Prey Preferences in Terrestrial Habitats (percent of diet)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
Numprey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Numreceptor																				
1 Alligator snapping turtle	0	0.1	0.1	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0.8
2 American kestrel	0.05	0.51	0.51	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.49
3 American robin	0.27	0.93	0	0	0	0	0	0	0	0	0.92	0	0.24	0	0	0	0.01	0	0	0
4 American woodcock	1	0.16	0	0	0	0	0	0	0	0	0	0	0.11	0	0	0	0.01	0	0	0
5 Bald eagle	0	0.1	0.34	0.34	0.34	0.53	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.1
6 Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0.1	0	0.01	0	0	0
7 Belted kingfisher	0	0.71	0.1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0.01	0	0	0.27
8 Black bear	0	0.5	0.1	0.1	0.1	0	0	0	0	0	0.5	0.1	0.3	0	0.05	0.05	0.01	0	0	0.1
9 Black-tailed jack rabbit	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.01	0	0	0
11 Burrowing owl	0	0.9	0.68	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.1
12 Canada goose	0	0.1	0	0	0	0	0	0	0	0	0	0	1	1	0.37	1	0.01	0	0	0
13 Cerulean warbler	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
14 Cooper's hawk	0	0	0.71	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
15 Coyote	0	0.1	0.73	0.2	0.2	0.28	0	0	0	0	0.2	0	0	0	0	0	0.01	0	0	0.1
16 Deer mouse	0	0.58	0	0	0	0	0	0	0	0	0.46	0.1	0.41	0.65	0	0	0.01	0	0	0
17 Eastern box turtle	0.6	0.22	0.1	0	0	0	0	0	0	0	0.33	0.1	0.39	0	0	0	0.01	0	0	0.1
18 Eastern cotton tail	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.25	0.01	0	0	0
22 Great basin pocket mouse	0	0.25	0	0	0	0	0	0	0	0	0	0	0.14	0.85	0	0	0.01	0	0	0
23 Great blue heron	0	0.09	0.23	0	0	0.02	0	0	0	0	0	0	0.63	0	0	0	0.01	0	0	0.23
25 Green heron	0.21	0.84	0.05	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0.01	0	0	0.1
26 Herring gull	0.1	0.38	0.78	0	0	0.3	0	0	0	0	0.1	0	0.16	0	0	0	0.01	0	0	0.02

(continued)

Table 12B-2a. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
27 Kit fox	0	0.1	0.94	0.94	0.94	0.1	0	0	0	0	0.1	0	0.1	0	0	0	0.01	0	0	0.1
28 Least weasel	0	0.1	1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
29 Lesser scaup	0	0.69	0	0	0	0	0	0	0	0	0.1	0	0.1	1	0	0	0.01	0	0	0
30 Little brown bat	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 Loggerhead shrike	0	0.96	0.76	0	0	0.76	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25
32 Long-tailed weasel	0.1	0.1	0.82	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
33 Mallard duck	0	0.6	0	0	0	0	0	0	0	0	0.24	0	0.1	1	0.1	0.25	0.01	0	0	0
34 Marsh wren	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
35 Meadow vole	0	0.05	0	0	0	0	0	0	0	0	0.2	0.1	1	0.25	0.34	0.25	0.01	0	0	0
36 Mink	0	0.63	0.43	0.43	0	0.33	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.39
37 Mule deer	0	0	0	0	0	0	0	0	0	0	0.25	0.6	0.94	0.1	0	0.1	0.01	0	0	0
38 Muskrat	0	0	0	0	0	0	0	0	0	0	0	0.1	0.81	0.1	0.1	0	0.01	0	0	0.1
39 Northern bobwhite	0	0.36	0	0	0	0	0	0	0	0	0.25	0	0.25	0.92	0	0	0.01	0	0	0
40 Northern water snake	0	0.25	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.83
41 Osprey	0	0	1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.05
42 Painted turtle	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
43 Pine vole	0	0.1	0	0	0	0	0	0	0	0	0.1	0.1	0.96	0.21	0.5	0	0.01	0	0	0
44 Prairie vole	0	0.25	0	0	0	0	0	0	0	0	0.25	0.1	1	0.25	0.25	0	0.01	0	0	0
45 Raccoon	0.1	0.9	0.35	0	0	0.19	0	0	0	0	0.86	0	0.66	0.1	0.1	0.1	0.01	0	0	0.25
46 Racer	0	0.64	0.62	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.67
47 Red fox	0	0.25	0.92	0.1	0.1	0.46	0	0	0	0	0.5	0	0.1	0	0	0	0.01	0	0	0
48 Red-tailed hawk	0.1	0.25	0.9	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25
49 River otter	0	0.25	0.25	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25
50 Short-tailed shrew	0.5	0.5	0.1	0	0	0	0	0	0	0	0.1	0.25	0	0	0	0	0.01	0	0	0
51 Short-tailed weasel	0	0.25	0.8	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25

(continued)

Table 12B-2a. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
52 Snapping turtle	0.1	0.25	0.25	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.45
53 Southern hognose snake	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	1
54 Spotted sandpiper	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
55 Tree swallow	0	0.78	0	0	0	0	0	0	0	0	0.25	0	0.25	0	0	0	0.01	0	0	0
56 Western meadow lark	0	1	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.01	0	0	0
57 White-tailed deer	0	0	0	0	0	0	0	0	0	0	0.4	0.25	1	0.78	0	0.78	0.01	0	0	0

Shaded values are not real values; they were entered to make the sum of the MaxPreyPref greater than1.
The species for which these values were entered do not occur in these (terrestrial) habitats, and were used as placeholders in this table. The little brown bat does occur in terrestrial habitats but eats only one prey item (invertebrates).
0 denotes a null value. The species does not consume the particular prey item.

Table 12B-2b. Maximum Prey Preferences in Waterbody Margin and Wetland Margin Habitats (percent of diet)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
Numprey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Numreceptor																				
1 Alligator snapping turtle	0	0.1	0.1	0	0	0	0.6	0.6	0.6	0.2	0.2	0	0	0	0	0	0	0.01	0.01	0.6
2 American kestrel	0.05	0.51	0.51	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.49
3 American robin	0.27	0.93	0	0	0	0	0	0	0	0	0.92	0	0.24	0	0	0	0.01	0	0	0
4 American woodcock	1	0.16	0	0	0	0	0	0	0	0	0	0	0.11	0	0	0	0.01	0	0	0
5 Bald eagle	0	0.1	0.34	0.34	0.34	0.53	0	0.74	0.74	0	0	0	0	0	0	0	0.01	0.01	0.01	0.1
6 Beaver	0	0	0	0	0	0	0	0	0	0.9	0	0	0.9	0	0.1	0	0.01	0.01	0.01	0
7 Belted kingfisher	0	0.41	0.1	0	0	0	0.1	1	0	0	0	0	0.1	0	0	0	0.01	0.01	0.01	0.27
8 Black bear	0	0.5	0.1	0.1	0.1	0	0.05	0.3	0.3	0	0.5	0.1	0.3	0	0.05	0.05	0.01	0.01	0.01	0.1
9 Black-tailed jackrabbit	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.01	0	0	0
11 Burrowing owl	0	0.9	0.68	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.1
12 Canada goose	0	0.1	0	0	0	0	0	0	0	0.2	0	0	1	1	0.37	1	0.01	0.01	0.01	0
13 Cerulean warbler	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
14 Cooper's hawk	0	0	0.71	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
15 Coyote	0	0.1	0.73	0.2	0.2	0.28	0	0	0	0	0.2	0	0	0	0	0	0.01	0	0	0.1
16 Deer mouse	0	0.58	0	0	0	0	0	0	0	0	0.46	0.1	0.41	0.65	0	0	0.01	0	0	0
17 Eastern box turtle	0.6	0.22	0.1	0	0	0	0	0	0	0	0.33	0.1	0.39	0	0	0	0.01	0	0	0.1
18 Eastern cottontail rabbit	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.25	0.01	0	0	0
22 Great basin pocket mouse	0	0.25	0	0	0	0	0	0	0	0	0	0	0.14	0.85	0	0	0.01	0	0	0
23 Great blue heron	0	0.09	0.23	0	0	0.02	0.09	0.98	0.98	0.33	0	0	0.33	0	0	0	0.01	0.01	0.01	0.23

(continued)

Table 12B-2b. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
25 Green heron	0.21	0.24	0.05	0	0	0	0	0.9	0	0.03	0	0	0.03	0	0	0	0.01	0.01	0.01	0.1
26 Herring gull	0.1	0.38	0.78	0	0	0.3	0.38	0.73	0.73	0.16	0.1	0	0.16	0	0	0	0.01	0.01	0.01	0.02
27 Kit fox	0	0.1	0.94	0.94	0.94	0.1	0	0	0	0	0.1	0	0.1	0	0	0	0.01	0	0	0.1
28 Least weasel	0	0.1	1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
29 Lesser scaup	0	0.69	0	0	0	0	0.25	0	0	0.1	0.1	0	0.1	1	0	0	0.01	0.01	0.01	0
30 Little brown bat	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 Loggerhead shrike	0	0.96	0.76	0	0	0.76	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25
32 Long-tailed weasel	0.1	0.1	0.82	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0
33 Mallard duck	0	0.6	0	0	0	0	0.1	0.1	0	0.1	0.24	0	0.1	1	0.1	0.25	0.01	0.01	0.01	0
34 Marsh wren	0	1	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0.01	0	0.01	0
35 Meadow vole	0	0.05	0	0	0	0	0	0	0	0	0.2	0.1	1	0.25	0.34	0.25	0.01	0	0	0
36 Mink	0	0.63	0.43	0.43	0	0.33	0	0.9	0.9	0	0	0	0	0	0	0	0.01	0.01	0.01	0.39
37 Mule deer	0	0	0	0	0	0	0	0	0	0	0.25	0.6	0.94	0.1	0	0.1	0.01	0	0	0
38 Muskrat	0	0	0	0	0	0	0.5	0.1	0	0.91	0	0.1	0.81	0.1	0.1	0	0.01	0.01	0.01	0.1
39 Northern bobwhite	0	0.36	0	0	0	0	0	0	0	0	0.25	0	0.25	0.92	0	0	0.01	0	0	0
40 Northern water snake	0	0.25	0.12	0	0	0	0.05	0.75	0.5	0	0	0	0	0	0	0	0	0.01	0.01	0.53
41 Osprey	0	0	0.05	0	0	0.1	0	1	1	0	0	0	0	0	0	0	0.01	0.01	0.01	0.05
42 Painted turtle	0	0.25	0	0	0	0	0	0.13	0	1	0	0	0	0	0	0	0.01	0.01	0.01	0
43 Pine vole	0	0.1	0	0	0	0	0	0	0	0	0.1	0.1	0.96	0.21	0.5	0	0.01	0	0	0
44 Prairie vole	0	0.25	0	0	0	0	0	0	0	0	0.25	0.1	1	0.25	0.25	0	0.01	0	0	0
45 Raccoon	0.1	0.9	0.35	0	0	0.19	0.25	0.23	0.23	0	0.86	0	0.66	0.1	0.1	0.1	0.01	0.01	0.01	0.25
46 Racer	0	0.64	0.62	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.67
47 Red fox	0	0.25	0.92	0.1	0.1	0.46	0	0	0	0	0.5	0	0.1	0	0	0	0.01	0	0	0
48 Red-tailed hawk	0.1	0.25	0.9	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25

(continued)

Table 12B-2b. (continued)

	Worms	Other Invertebrates	Small Mammals	Herbivorous Vertebrates	Omnivorous Vertebrates	Small Birds	Benthic Filter Feeders	T3 Fish	T4 Fish	Aquatic Plants	Exposed Fruits	Exposed Vegetables	Forage	Grains	Roots	Silage	Soil	Sediment	Water	Small Herpetofauna
49 River otter	0	0.25	0.25	0	0	0.25	0.1	0.94	0.94	0	0	0	0	0	0	0	0.01	0.01	0.01	0.25
50 Short-tailed shrew	0.5	0.5	0.1	0	0	0	0	0	0	0	0.1	0.25	0	0	0	0	0.01	0	0	0
51 Short-tailed weasel	0	0.25	0.8	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.25
52 Snapping turtle	0.1	0.25	0.25	0	0	0.1	0.25	0.84	0.84	0.25	0	0	0	0	0	0	0.01	0.01	0.01	0.25
53 Southern hognose snake	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	1
54 Spotted sandpiper	0	1	0	0	0	0	0.25	0.25	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0
55 Tree swallow	0	0.78	0	0	0	0	0	0	0	0	0.25	0	0.25	0	0	0	0.01	0	0	0
56 Western meadowlark	0	1	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.01	0	0	0
57 White-tailed deer	0	0	0	0	0	0	0	0	0	0.25	0.4	0.25	1	0.78	0	0.78	0.01	0	0	0

* 0 denotes a null value. The species does not consume the particular prey item.

Appendix 12C

Home Range Parameters for Ecological Receptors

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Table 12C-1. Receptor Home Ranges and Bins

Receptor Index	Receptor Species	Home Range (min) m^2	Home Range (max)m^2	Home Range (midpt) m^2
	Bin 1 :hr =/<100,000 m^2			
19	Eastern newt	28	153	91
20	Flatwood slamander	100	100	100
21	Gopher frog[1]	7	200	104
24	Green frog	7	200	104
10	Bullfrog	1	400	201
35	Meadow vole	2	830	416
44	Prairie vole	73	980	527
16	Deer mouse	140	1,280	710
38	Muskrat	480	1,700	1,090
34	Marsh wren	156	2,600	1,378
54	Spotted sandpiper	2,500	2,500	2,500
30	Little brown bat	2,549	2,549	2,549
3	American robin	1,100	8,400	4,750
28	Least weasel	8,000	8,000	8,000
50	Short-tailed shrew	300	18,000	9,150
22	Great basin pocket mouse	500	24,000	12,250
40	Northern water snake[1]	18,000	30,000	24,000
53	Southern hognose snake[1]	18,000	30,000	24,000
46	Racer	18,000	30,000	24,000
17	Eastern box turtle	4,600	52,000	28,300
43	Pine vole	310	68,800	34,555
18	Eastern cottontail rabbit	8,000	78,000	43,000
42	Painted turtle[2]	2,400	83,800	43,100
52	Snapping turtle	2,400	83,800	43,100
7	Belted kingfisher[3]	6,000	84,000	45,000
25	Green heron[3]	6,000	84,000	45,000
31	Loggerhead shrike[3]	6,000	84,000	45,000
23	Great blue heron	6,000	84,000	45,000
56	Western meadowlark	12,000	130,000	71,000
	Bin 2: hr >100,000 and <1 million m^2			
39	Northern bobwhite	36,000	186,000	111,000
51	Short-tailed weasel	20,000	250,000	135,000
6	Beaver	164,084	164,084	164,084
9	Black-tailed jackrabbit	162,000	202,000	182,000
13	Cerulean warbler[4]	20,000	600,000	310,000
55	Tree swallow	20,000	600,000	310,000

(continued)

Table 12C-1. (continued)

Receptor Index	Receptor Species	Home Range (min) m^2	Home Range (max)m^2	Home Range (midpt) m^2
32	Long-tailed weasel	50,000	1,210,000	630,000
4	American woodcock	3,000	1,712,000	857,500
29	Lesser scaup	890,000	890,000	890,000
	Bin 3: hr = or >1 million and <10 million m^2			
11	Burrowing owl	400	4,810,000	2,405,200
2	American kestrel	97,000	5,000,000	2,548,500
57	White-tailed deer	590,000	8,040,000	4,315,000
33	Mallard duck	380,000	14,400,000	7,390,000
27	Kit fox	2,600,000	13,700,000	8,150,000
14	Cooper's hawk	180,000	18,000,000	9,090,000
	Bin 4: hr >10 million m^2			
37	Mule deer	1,286,800	21,227,200	11,257,000
48	Red-tailed hawk	600,000	24,650,000	12,625,000
47	Red fox	570,000	34,200,000	17,385,000
26	Herring gull[5]	18,300,000	18,800,000	18,550,000
41	Osprey[5]	18,300,000	18,800,000	18,550,000
5	Bald eagle	18,300,000	18,800,000	18,550,000
1	Alligator snapping turtle	180,000	38,480,000	19,330,000
45	Raccoon	53,000	49,460,000	24,756,500
36	Mink	78,000	78,540,000	39,309,000
15	Coyote	14,300,000	68,000,000	41,150,000
8	Black bear	79	177,000,000	88,500,040
12	Canada goose	1,800,000	1,029,220,000	515,510,000
49	River otter	2,950,000	19,113,450,000	9,558,200,000

[1] no data available. Home range data for the racer used.
[2] no data available. Home range data for the snapping turtle used.
[3] no data available. Home range data for the great blue heron used.
[4] no data available. Home range data for the tree swallow used.
[5] no data available. Home range data for the bald eagle used.